Why JPEG 2000?

Bernie Brower

NSES-Kodak

bernard.brower@kodak.com

+1 585 253 5293

Why JPEG 2000?

- Image Quality
  - JPEG 2000 will meet or exceed the current image quality requirements for all segments and applications within the NSGI architecture.

- Increased functionality
  - JPEG 2000 uses an embedded, progressively encoded bit stream for the compressed file. This enables the following kinds of scalability:
    - Progressive by accuracy (SNR), visual quality, and resolution (RRDS).
  - Markers are placed in compressed bit stream to give the decompressor many choices in decoding the file:
    - Any desired bit rate, resolution layer, or a tile (sub-image)
      - Today's algorithms are limited to given bit rates, single resolution, full image.
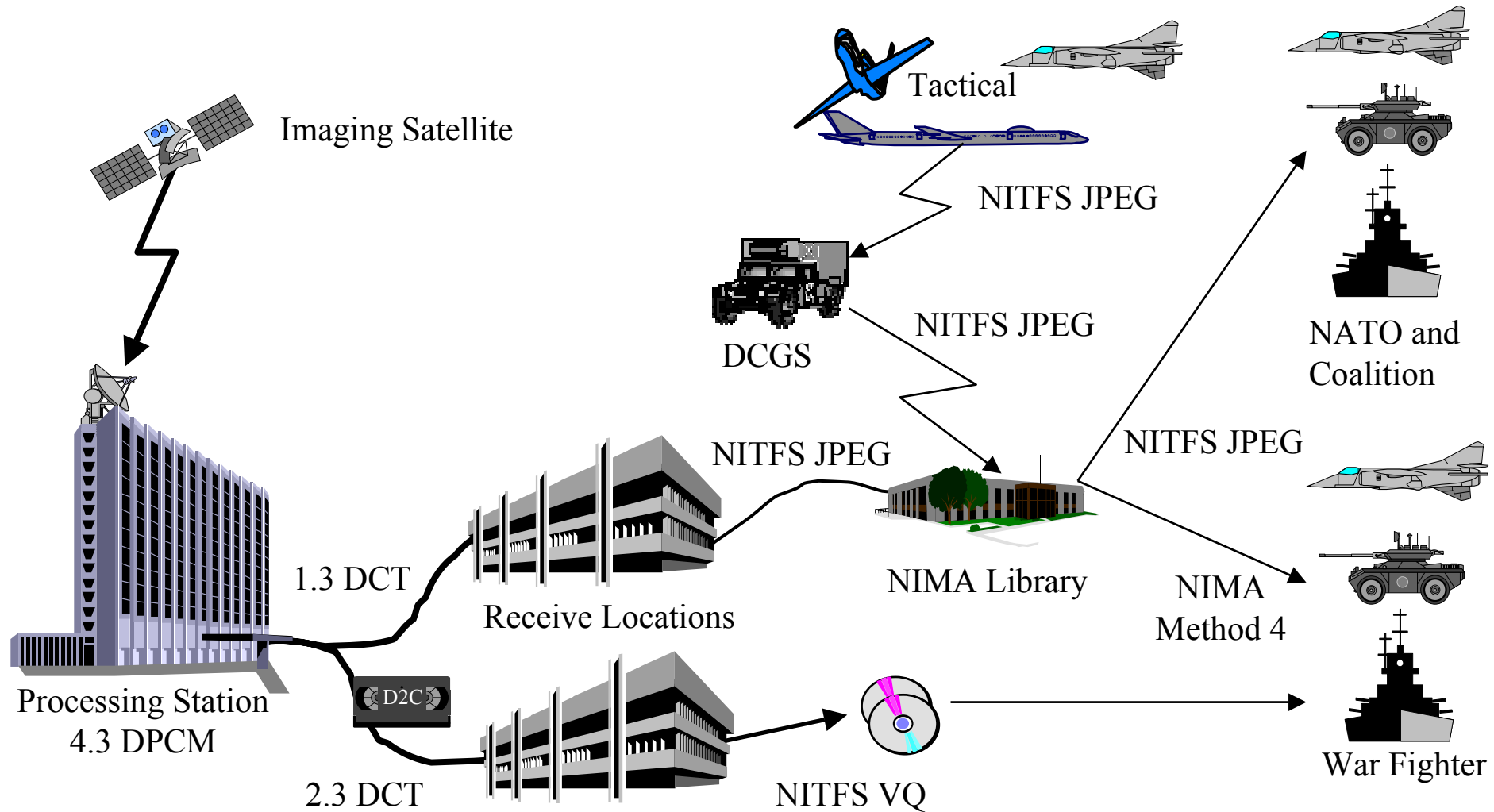 - Region of Interest (ROI) encoding.

Why JPEG 2000?

- JPEG 2000 is an international commercial standard, which makes it a logical solution from a cost and interoperability point of view as systems migrate to COTS products.
  - Several COTS systems support JPEG 2000 today
- JPEG 2000 will have the capability to handle multi-component imagery, allowing it to process MS/HS data.
- The single, unified compression standard will handle:
  - Any bit depth from 1 bpp (e.g. binary FAX) to 16 bpp.
  - Any arbitrary bit rate or quality that is desired, up to and including lossless.
    - Today's algorithms only operate at specific discrete rates (or quality levels for JPEG) and bit depths and thus are not as flexible.
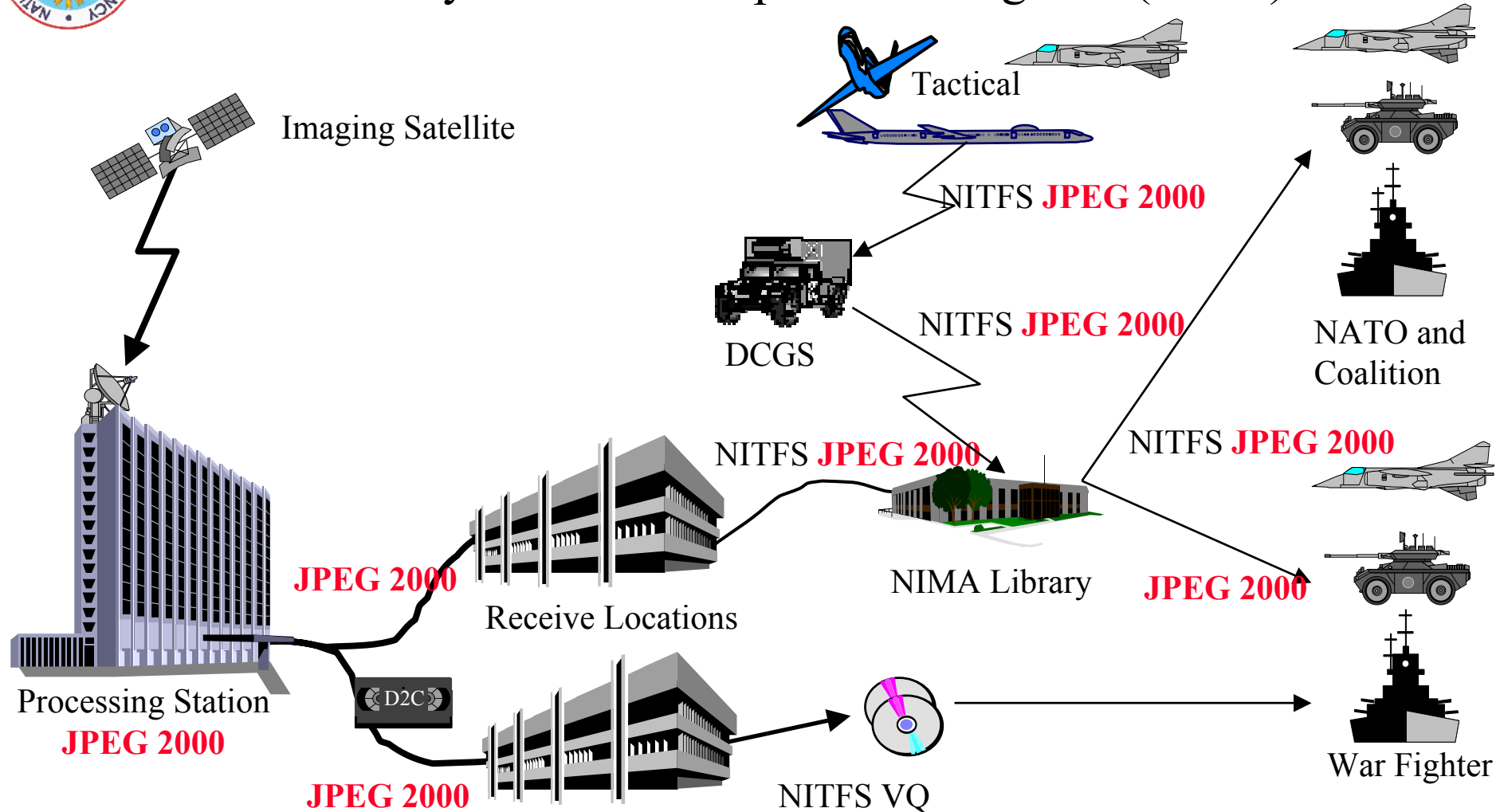 - Any image size no matter how big (i.e. with a tiling mechanism).

National System for Geospatial Intelligence (NSGI)

Imaging Satellite

Tactical

NITFS JPEG

DCGS

NITFS JPEG

NITFS JPEG

NATO and Coalition

NITFS JPEG

1.3 DCT

Receive Locations

NIMA Library

NIMA Method 4

Processing Station
4.3 DPCM

D2C

2.3 DCT

NITFS VQ

War Fighter

National System for Geospatial Intelligence (NSGI)

Imaging Satellite

Tactical

NITFS **JPEG 2000**

DCGS

NITFS **JPEG 2000**

NATO and Coalition

NITFS **JPEG 2000**

NITFS **JPEG 2000**

NIMA Library

Receive Locations

JPEG 2000

JPEG 2000

Processing Station
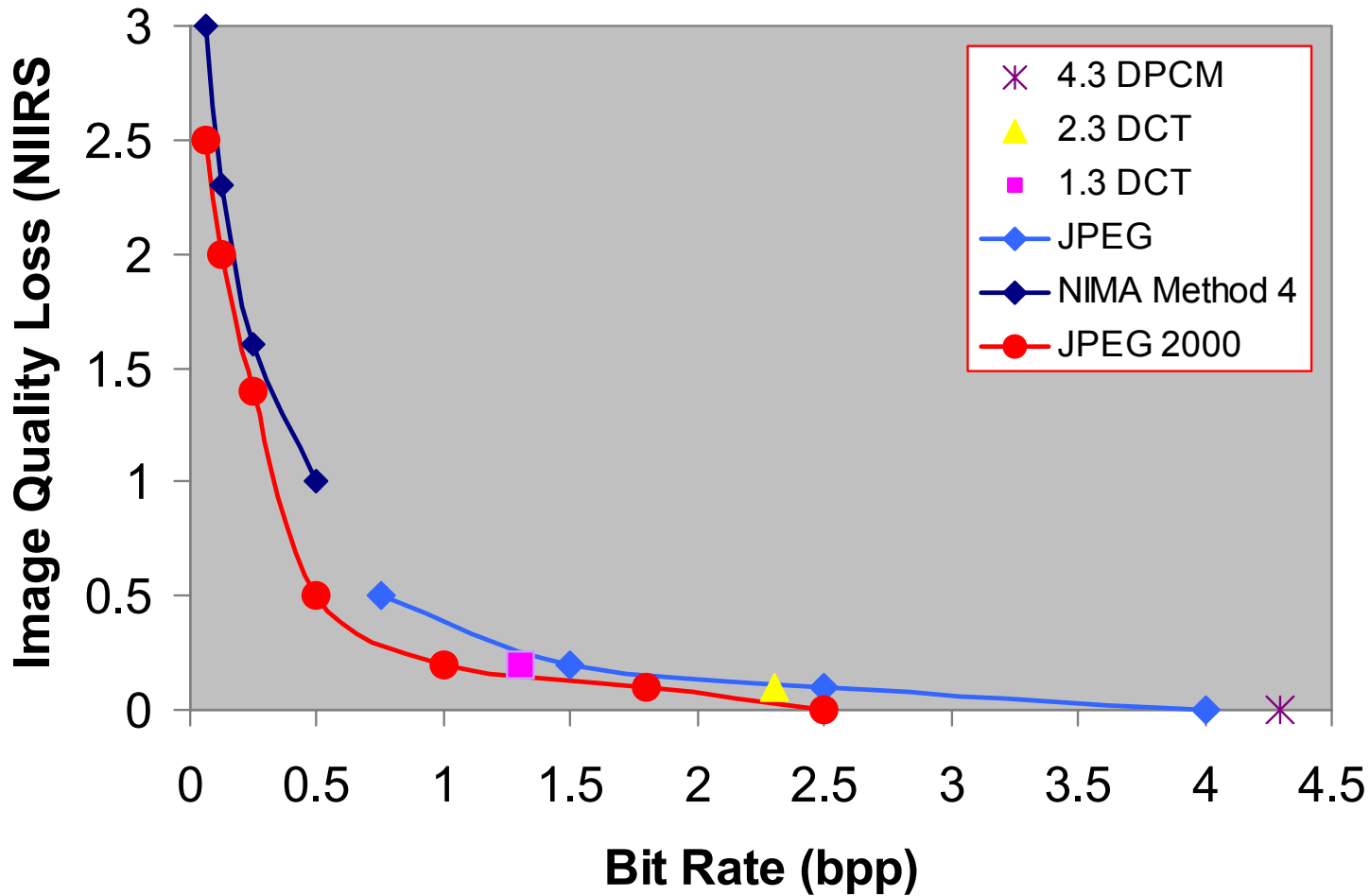**JPEG 2000**

D2C

JPEG 2000

NITFS VQ

War Fighter

Eight Compression algorithms used within the NSGI architecture

Meets or exceeds all current quality requirements

Compression image quality loss in todays USIGS

What makes JPEG 2000 Special

- With advances in compression science combined with advances in computers (speed and memory cost) JPEG 2000 has allowed a new compression paradigm to be born
- Advances in compression science
  - Wavelet transform
  - Bit plane arithmetic encoding
  - Embedded bit stream
- Advances in computers
  - Speed of CPU is fast enough to do more computation to achieve the same compression (more complicated compression algorithms)
  - Reduced cost of memory allows to take advantage of greater correlation lengths in an image
- A new paradigm is born
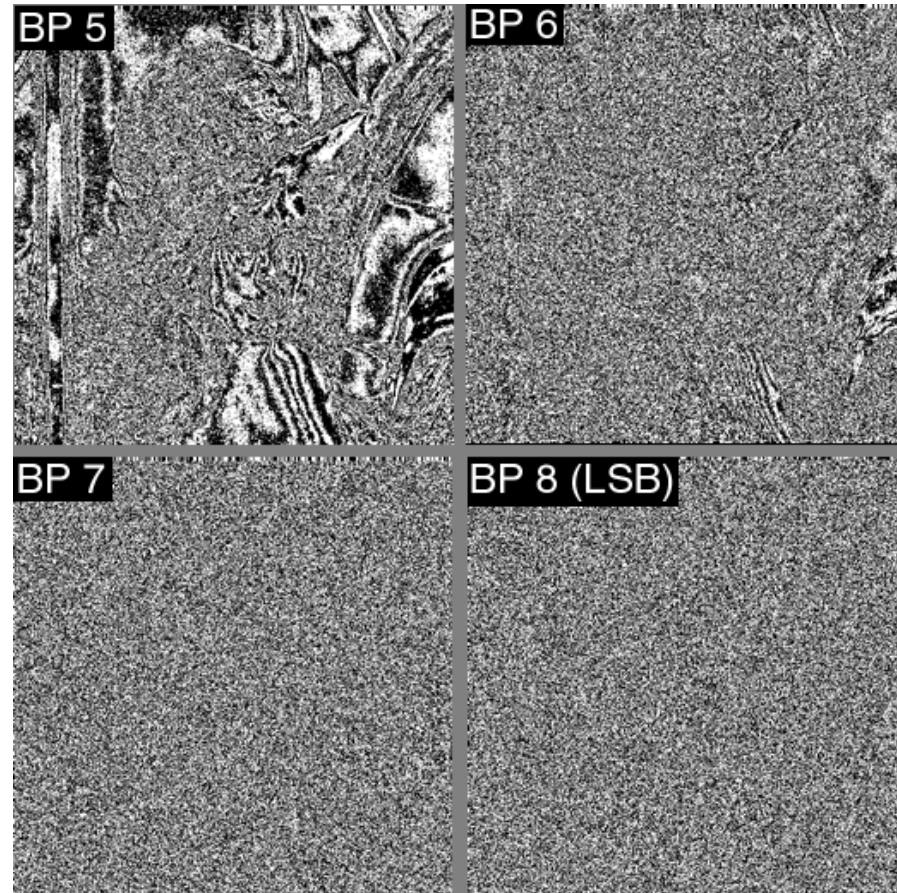 - Meets the requirements of the client/server environment

Wavelet transform of Lena Image
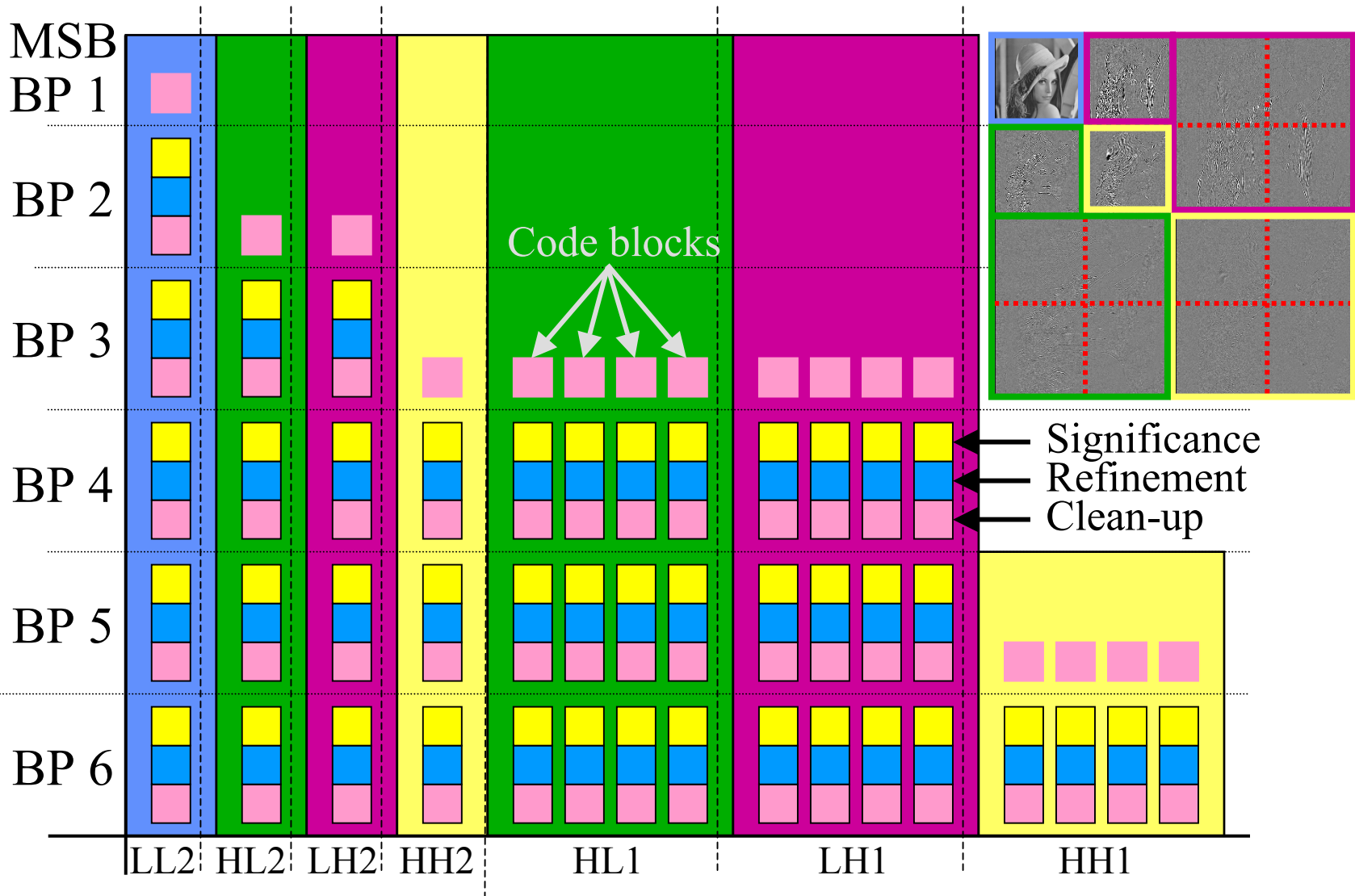## (Resolution Scalability)
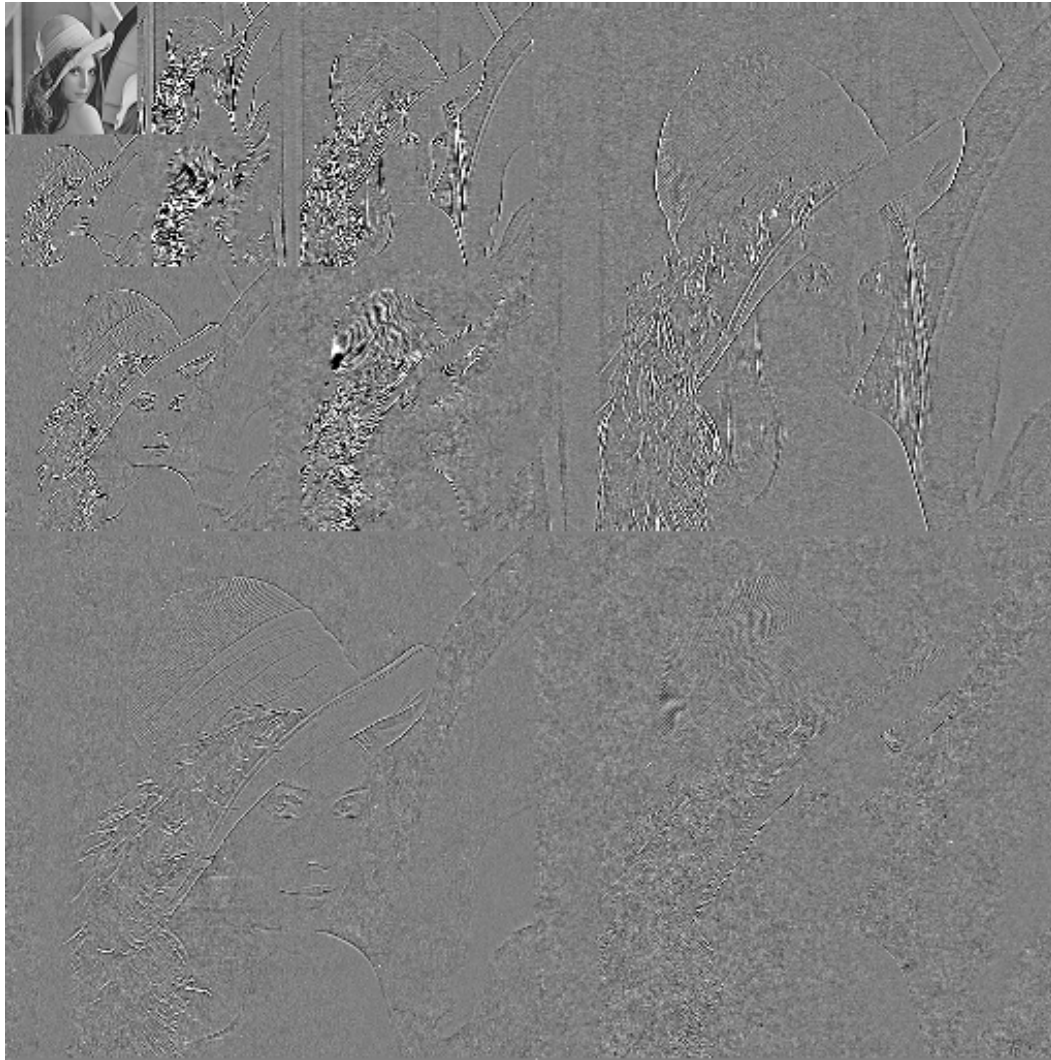
Bit Plane Encoding
(Quality Scalability)

Example of Bit-Plane Data Ordering
(Multiple Progression Orders)

MSB
BP 1

BP 2

Code blocks

BP 3

BP 4 — Significance, Refinement, Clean-up

BP 5

BP 6

LL2 | HL2 | LH2 | HH2 | HL1 | LH1 | HH1

Old Compression Paradigm

Encode

<u>Encoder choices</u>
color space
quantization
entropy coder
pre-processing

<u>No decoder choices</u>
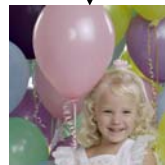only one image
post-processing

New Compression Paradigm

Encode choices

Old paradigm choices +
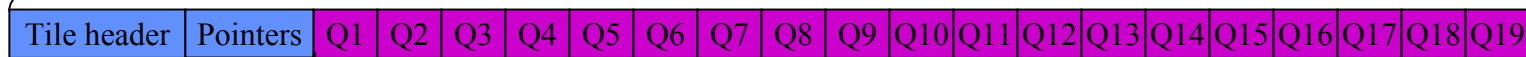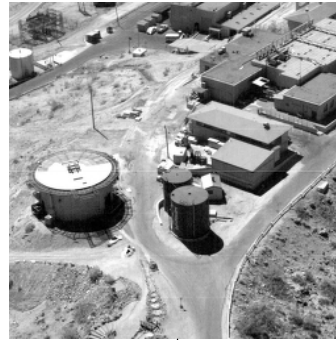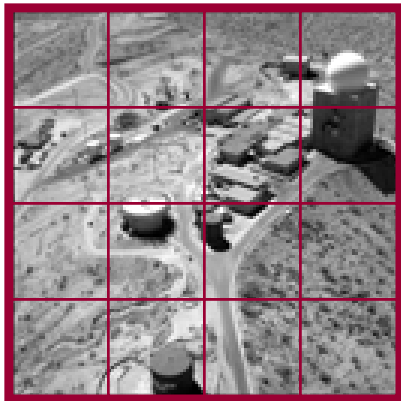Contone or binary
Tiling
Lossy/lossless

Encode

Decode choices

Image resolution
SNR fidelity
Visual fidelity
Target filesize
Component selection
Lossless/lossy
Region-of-interest

J2K Quality Progressive bit stream

| Image header | Pointers | Tile 1 | Tile 2 | Tile 3 | Tile 4 | Tile 5 | Tile 6 | Tile 7 | Tile 8 | Tile 9 | Tile 10 | Tile 11 | Tile 12 | Tile 13 | Tile 14 | Tile 15 | Tile 16 |

| Tile header | Pointers | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Q12 | Q13 | Q14 | Q15 | Q16 | Q17 | Q18 | Q19 |

Example of Progression by Quality

Original image was 8-bit uncompressed. All images extracted from a <u>single</u> 2.0 bpp compressed file.

With an embedded, progressively encoded bit stream, simply compress to high quality once and then decode the portion of the bit stream that meets your bandwidth requirements.

Example of Progression by Quality

Original image was 8-bit uncompressed. All images extracted from a <u>single</u> 2.0 bpp compressed file.

With an embedded, progressively encoded bit stream, simply compress to high quality once and then decode the portion of the bit stream that meets your bandwidth requirements.

Examples of Progression by Resolution

Commercial Software, IP, and Silicon

JPEG 2000 Software

AWARE

Power image

algoVision LuraTech

University of Victoria

DSPG@UVic
Digital Signal Processing Group

Kakadu

JPEG 2000 Firmware

ALMA TECHNOLOGIES

SYNOPSYS®

Adelante Technologies

AWARE

AMPHION

Power image

PICTURE ELEMENTS INCORPORATED
Pieces for picture-making systems

ateme

JPEG 2000 Silicon

ANALOG DEVICES

WIS TECHNOLOGIES

RICOH Image Communication
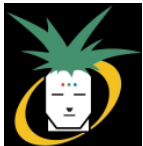
Commercial Products Supporting JPEG 2000

User Migration to JPEG 2000

- NIMA Standards
  - Funding the Development of JPEG 2000 Profile and Compliance testing
  - NIMA RFCs April 18 2002
    - 3.1.7.5.1.3.1.3.1 Compression/Decompression of data (NE095)
    - 3.2.2.5.3.1 Image data compression "compress FIA IOC1 data into standard JPEG 2000 format as defined in the NFRDD" (NE095)
- NIMA Airborne Office
  - Developing the migration planning for DCGS and tactical systems
- NATO Airgroup 4
  - Accepted JPEG 2000 for NSIF format (NATO's version of NITFS)
- Joint Interoperability Test Center
  - Developing the testing procedures for J2K within NITFS 2.1